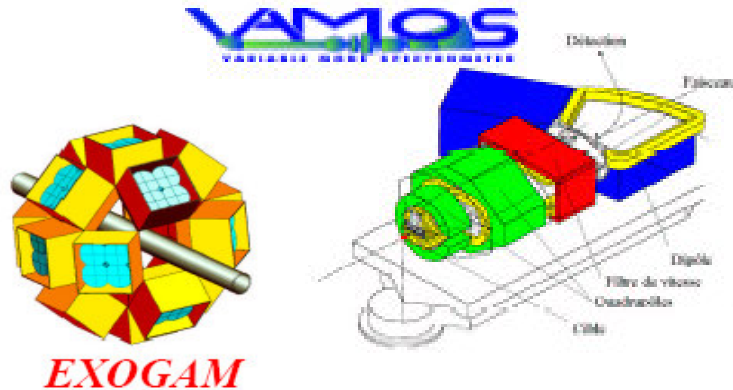


Spectroscopy of neutron-rich nuclei

Deep-inelastic collisions in inverse kinematics



SARMISHTHA BHATTACHARYYA
GANIL



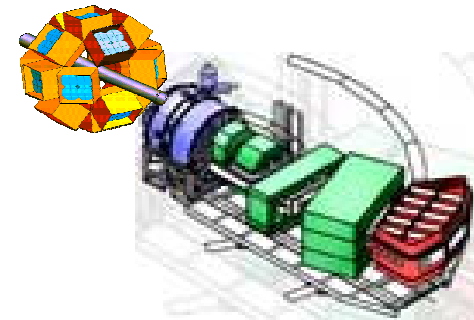
GAMMAPOOL WORKSHOP
ECT Trento, May 2006*

Plan of the talk

- *Physics motivation*
- *Experimental setup*
 - *EXOGAM and VAMOS*
 - *direct identification*
 - *inverse kinematics : ^{238}U beam*
- *Results*
 - *Deep / quasi inelastic reaction*
 - *population of very exotic nuclei*
- *Conclusion and perspectives*

*Search for neutron-rich
Calcium isotopes*

..... ^{54}Ca

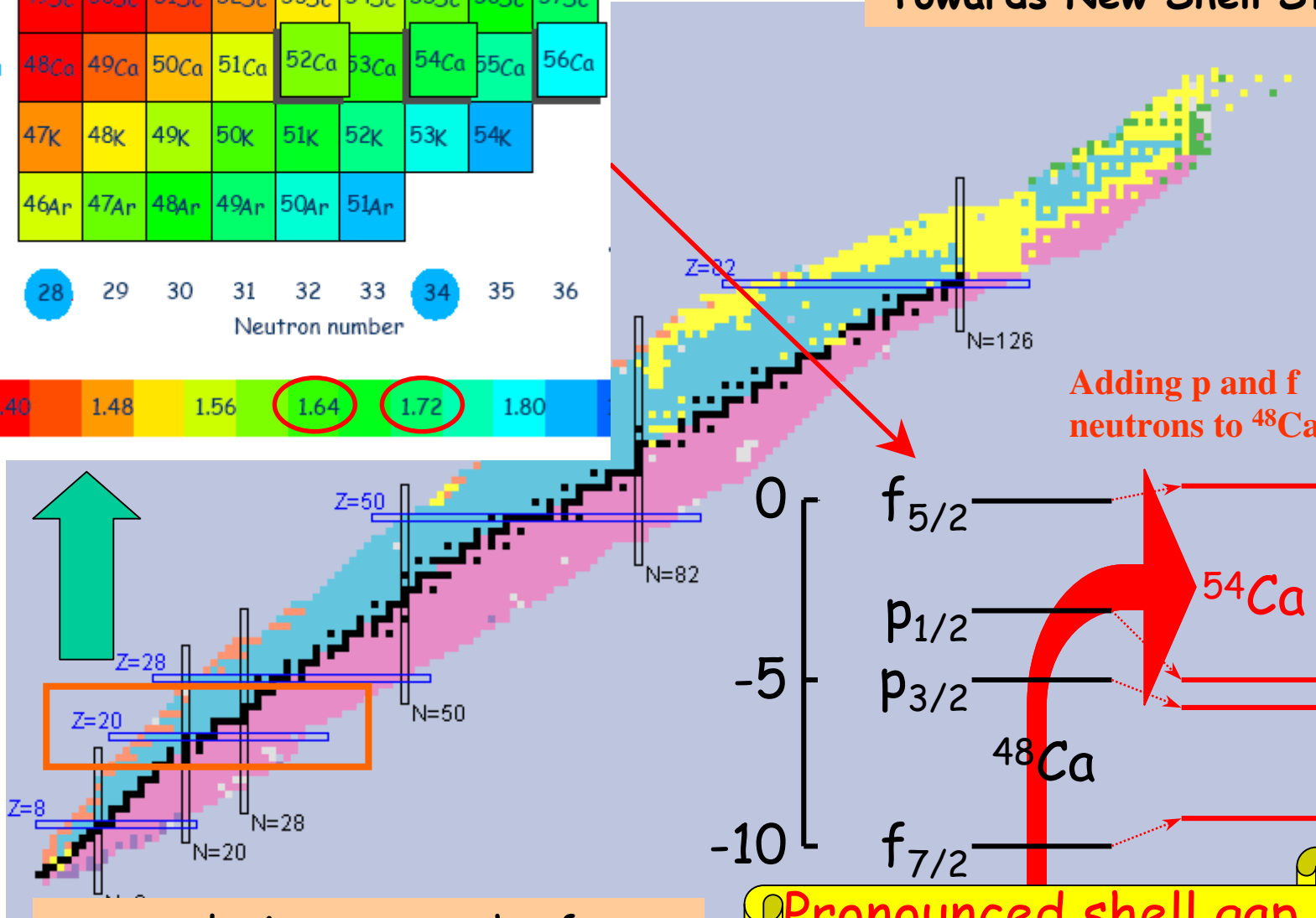
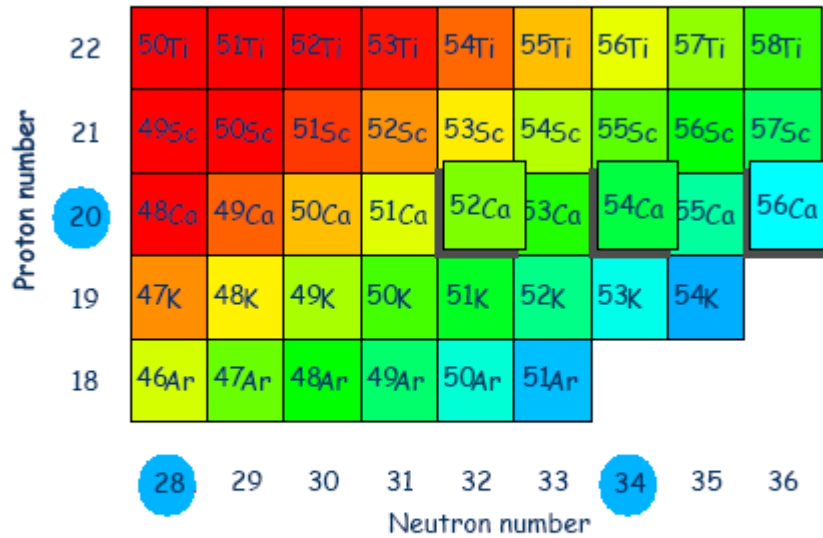


P, S, Cl, Ar, K, Ca, Sc, Ti

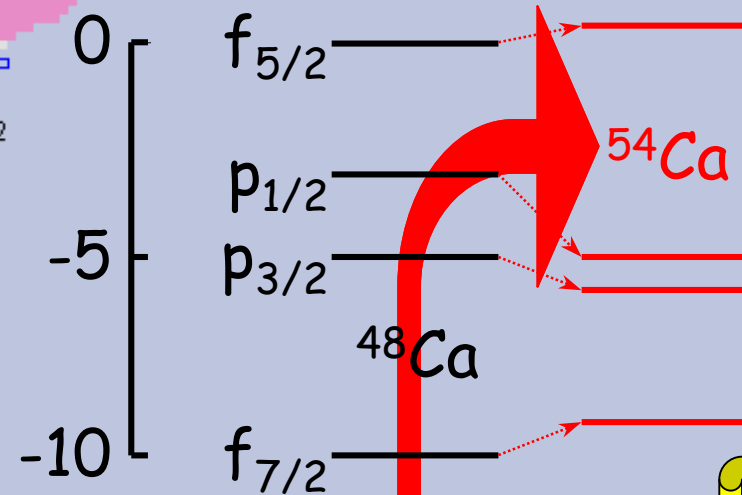
*Selectivity
High efficiency
Identification*

Physics Goal

Towards New Shell Structures



Adding p and f neutrons to ^{48}Ca



relative strength of neutron-neutron interaction between the orbitals

Pronounced shell gap in ^{54}Ca

Signature of Shell Closure

Fragmentation (GANIL)

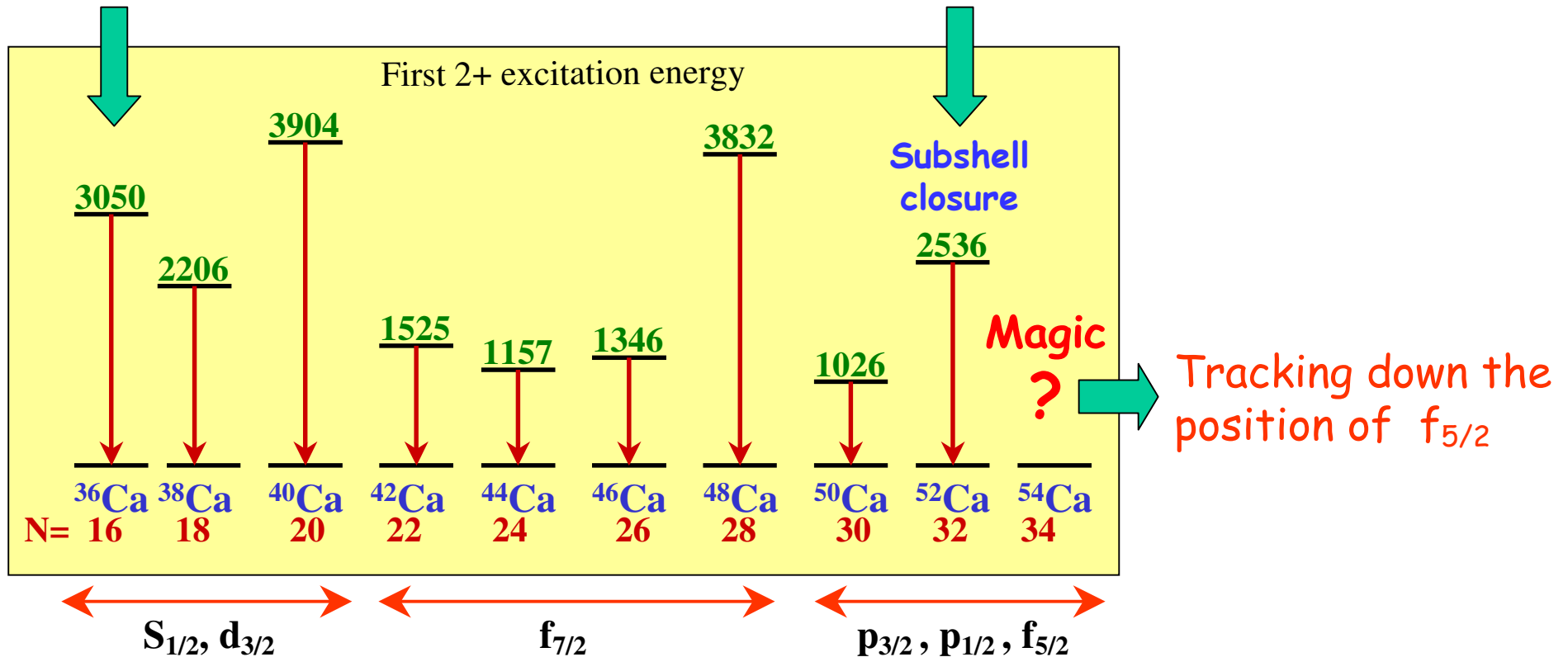
F. Azaiez et al

Beta decay studies

A.Huck et al., Phys. Rev. C 31, 2226 (1985).

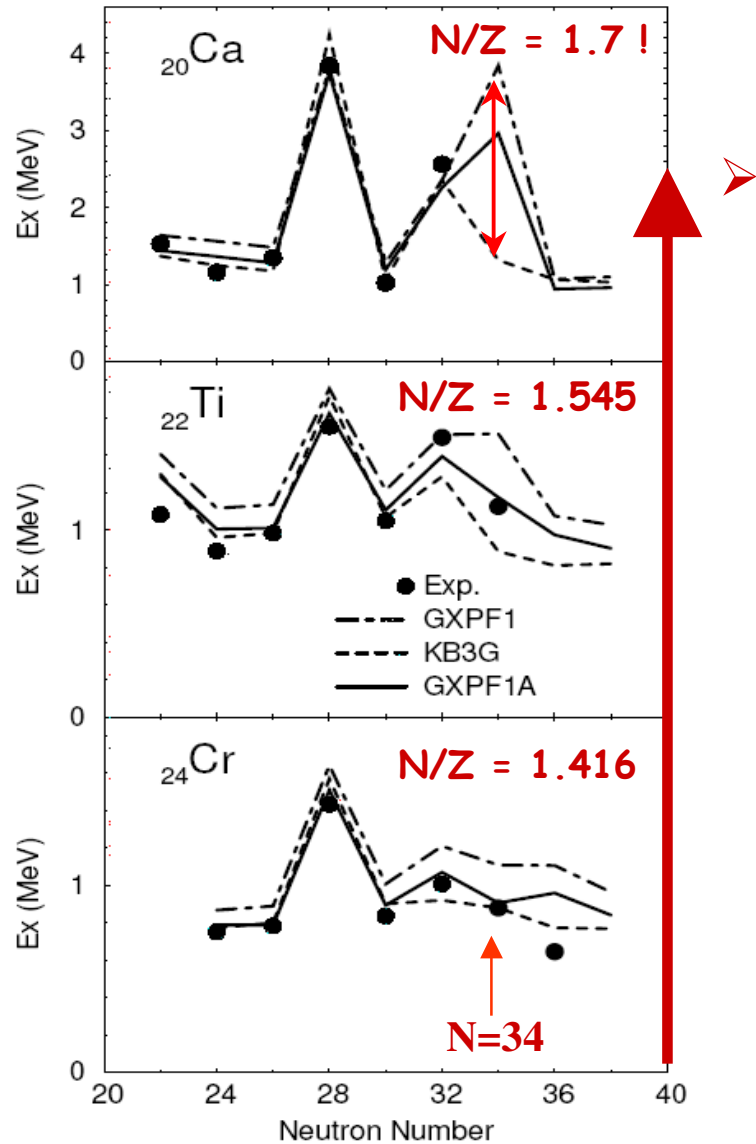
Fredric Perrot, Thesis, IreS, Strasbourg (2004)

No in-beam measurements



Information from higher excited states involving single particle excitation

Model Predictions ?



monopole shift of $n1f_{5/2}$ orbital with the removal of protons from $p1f_{7/2}$ orbital

➤ persistence of N=34 shell closure in Ca ?
 ^{54}Ca (N=34) Experimental Challenge
 2^+ energy ?

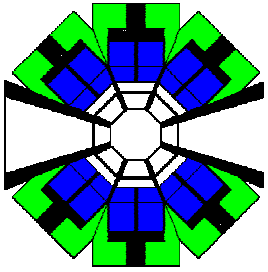
.....

^{56}Ti (N=34)
 2^+ energy is 1127 keV
 Liddik *et al*, PRL 92, 072502 (2004)
 PRC 70, 064303 (2004)

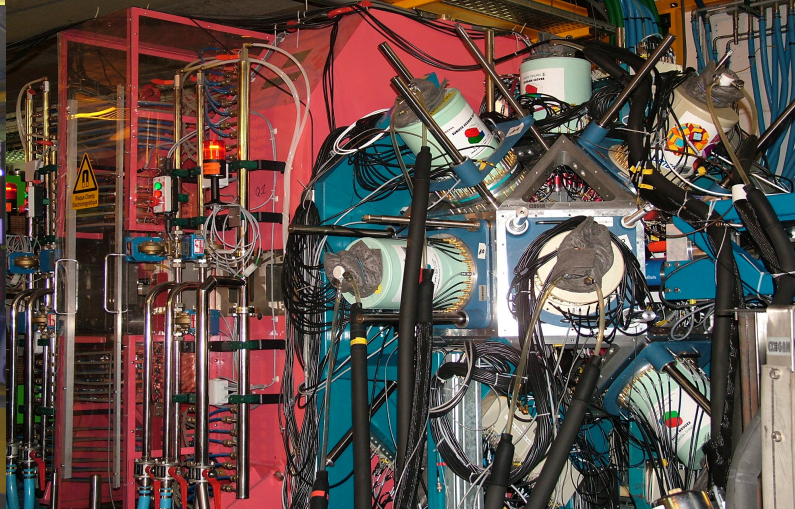
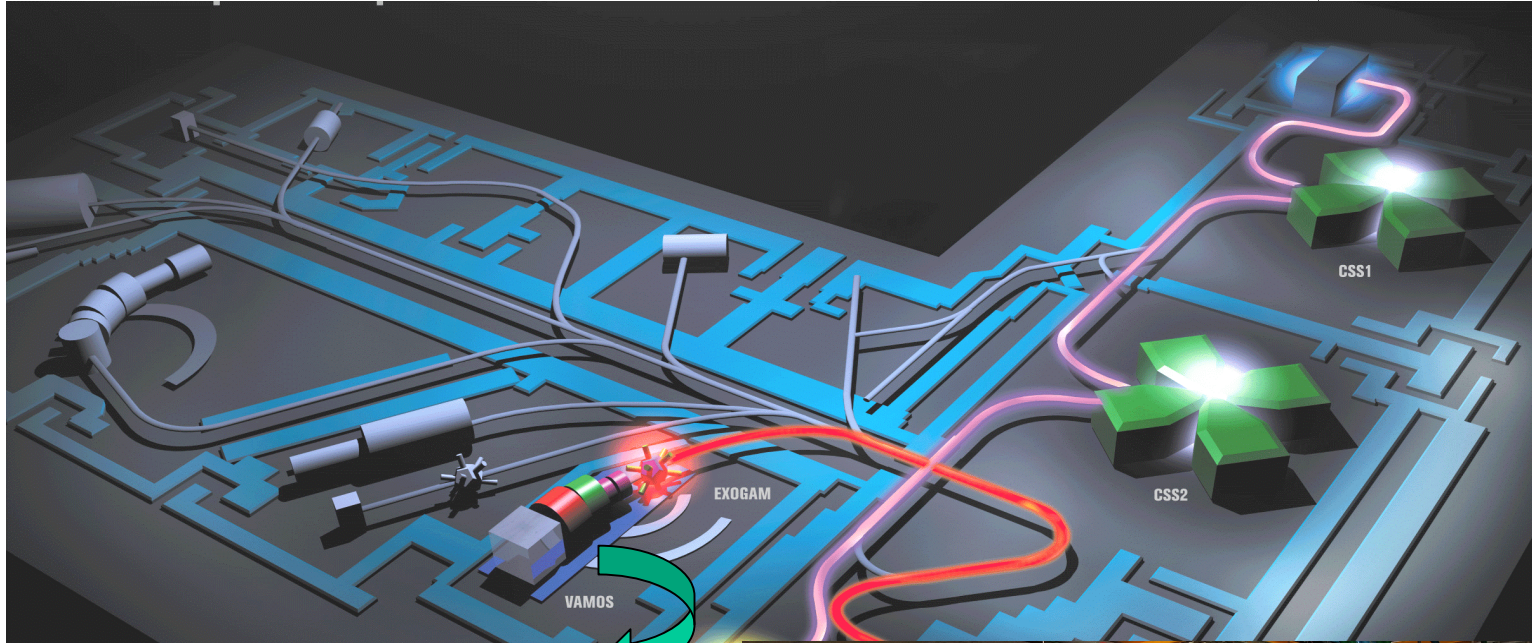
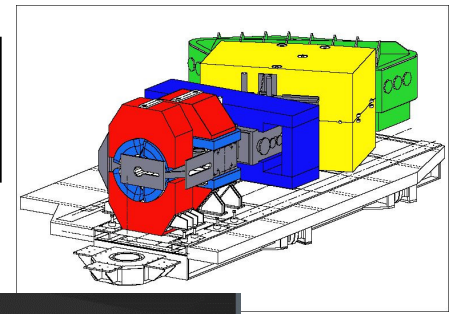
^{58}Cr (N=34)
 2^+ energy is 880 keV
 A.Bürger *et al*, PLB 622, 29 (2005)
 N.Marginean *et al*, PLB 633, 696 (2006)

M. Honma *et al*, EPJ A25, 499, 2005.

Way to go



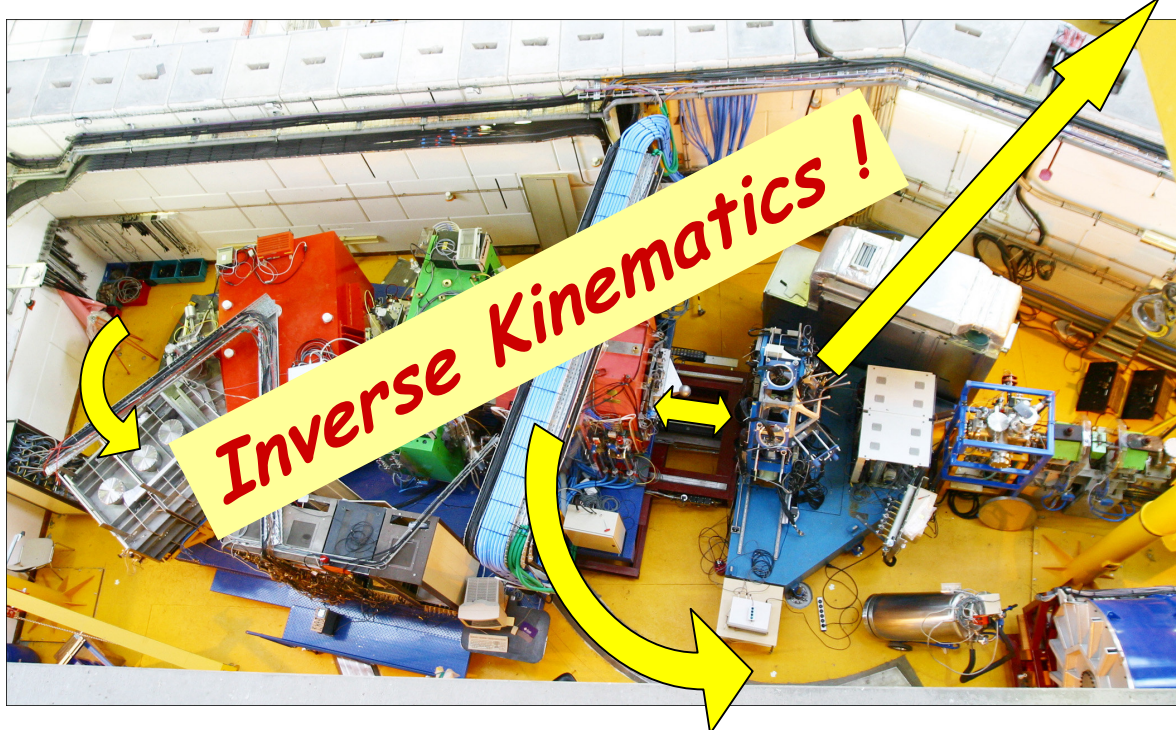
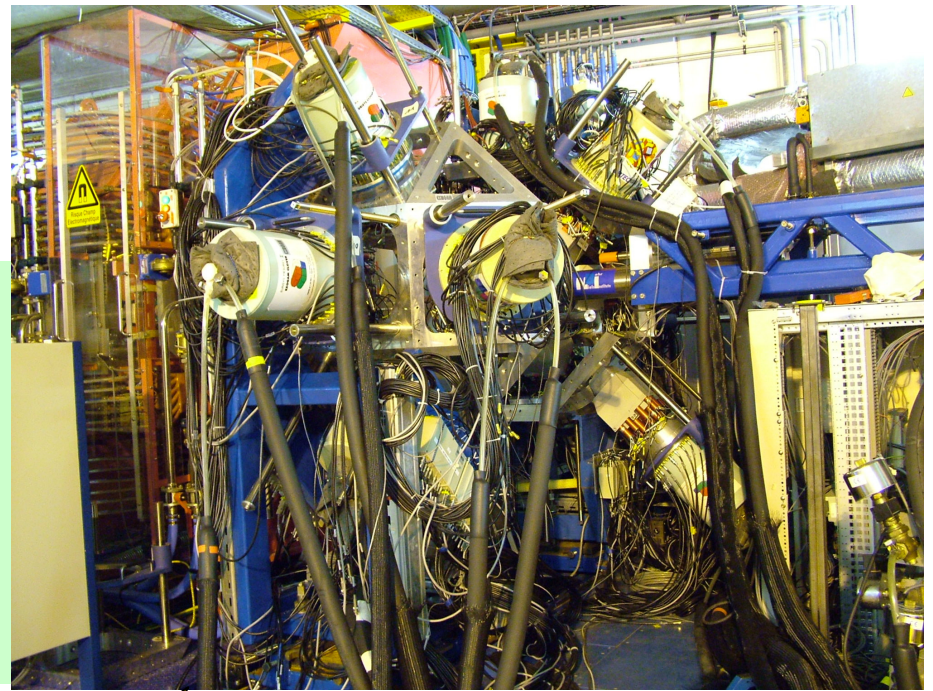
+



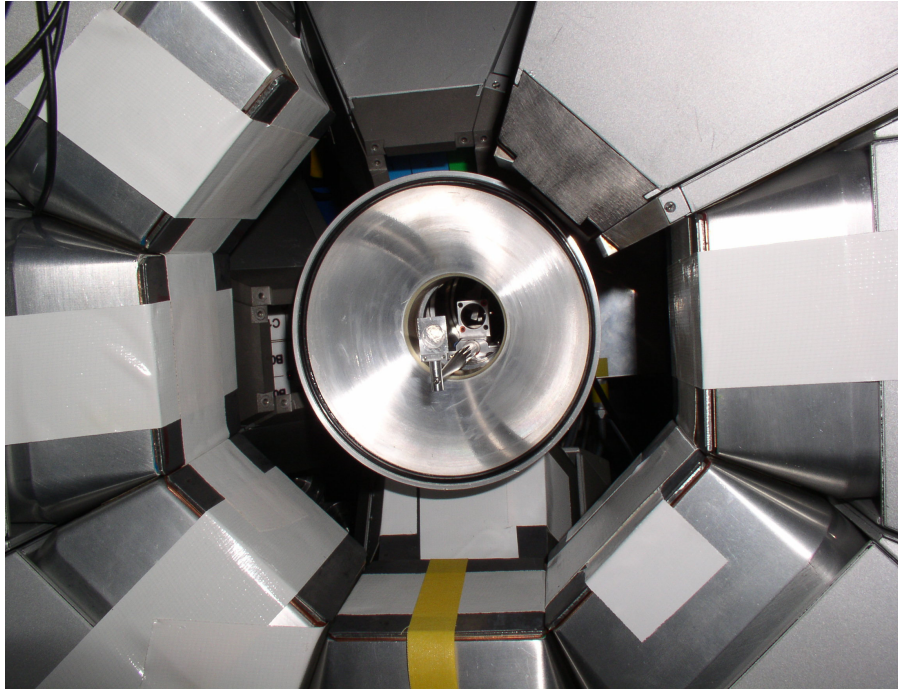
Deep inelastic reaction Tagging of recoil

Beam : ^{238}U @ 5.5 MeV/u
(N/Z=1.58) ~ 12% above barrier
(beam current ~ 2pA)

Target : ^{48}Ca (1 mg/cm²)
(N/Z=1.4)



- VAMOS + EXOGAM at 35° relative to beam - axis
- maximum scattering angle of projectile ~ 11°
- Inverse kinematics :
 - energetic target-like residues
 - covers larger angle



EXOGAM :

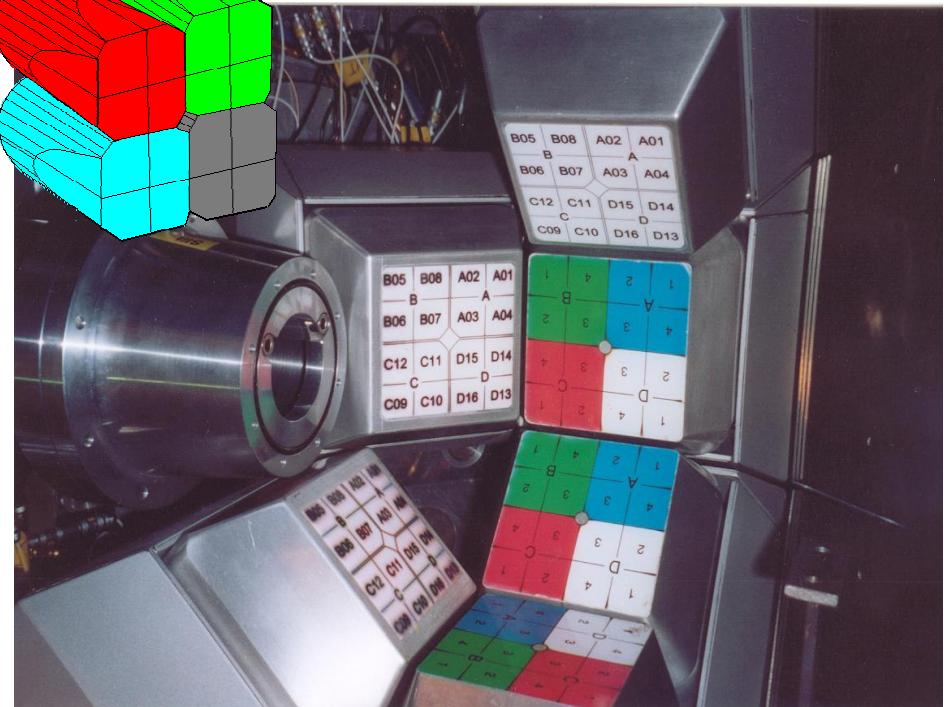
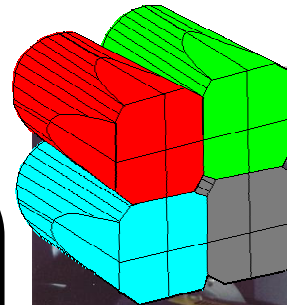
- 11 segmented Clover detectors partially Compton suppressed
- graded absorbers

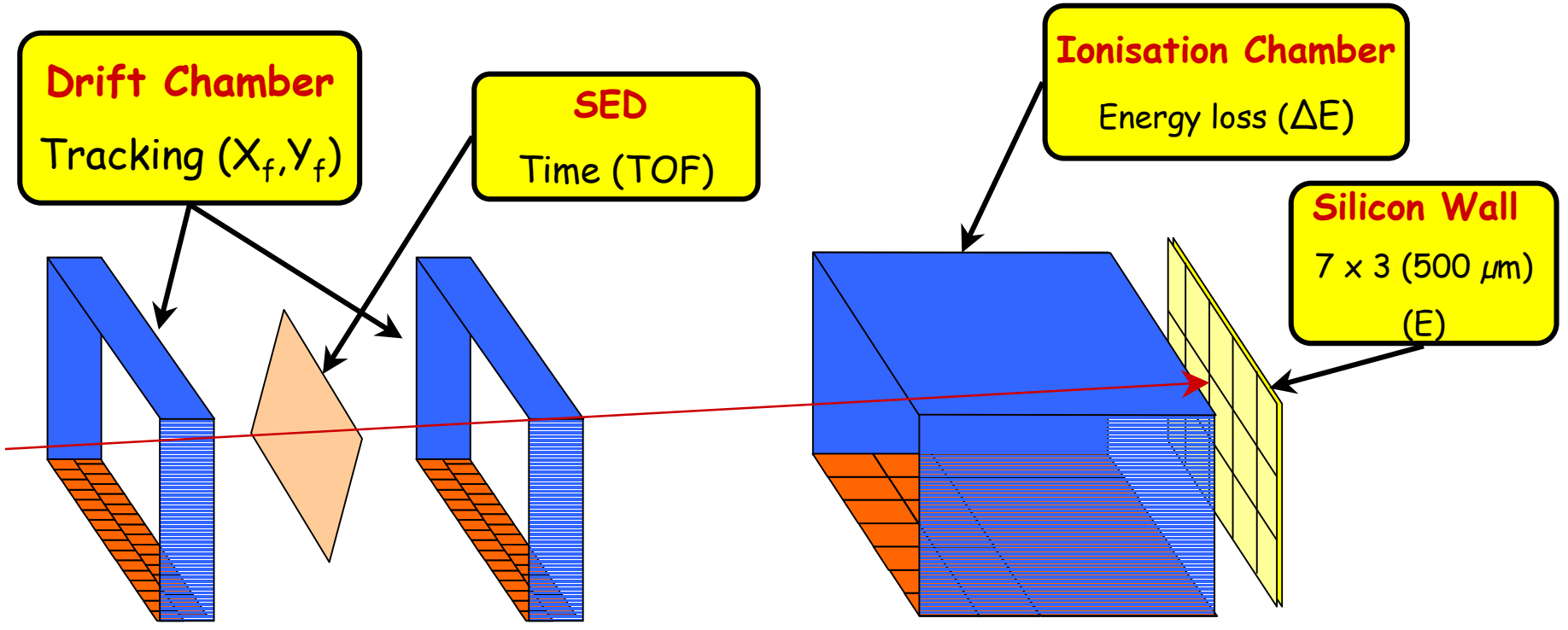
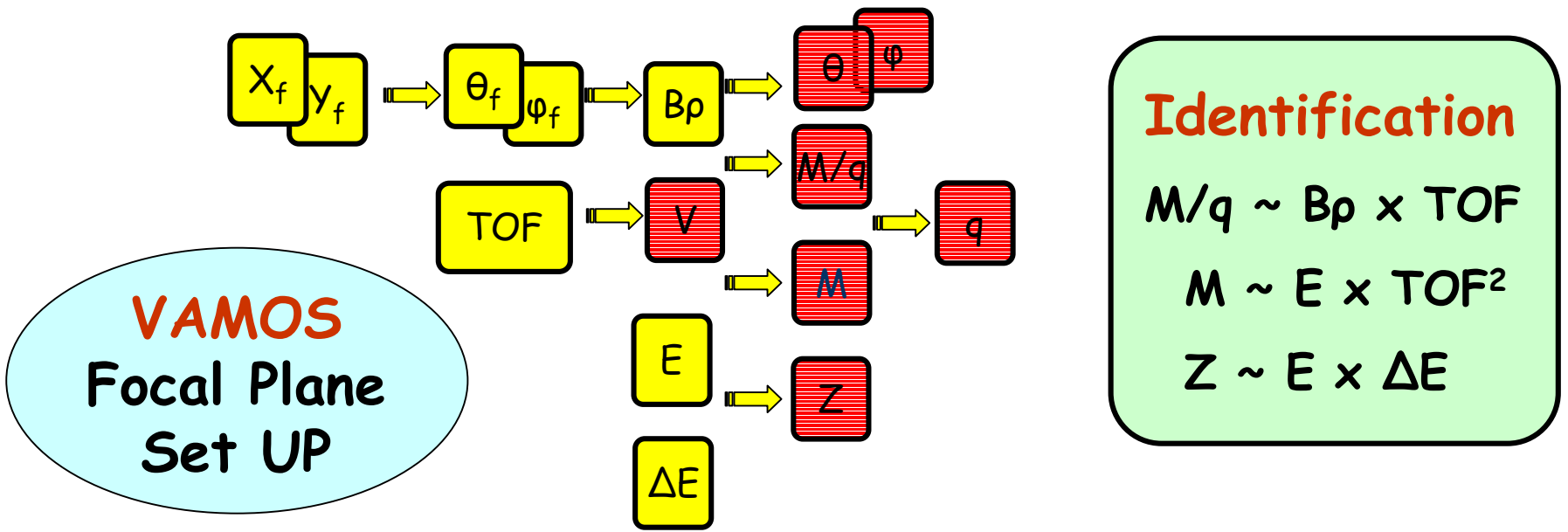
Total absolute Efficiency ~ 9% at 1 MeV

High v/c (~ 14%) of targetlike products

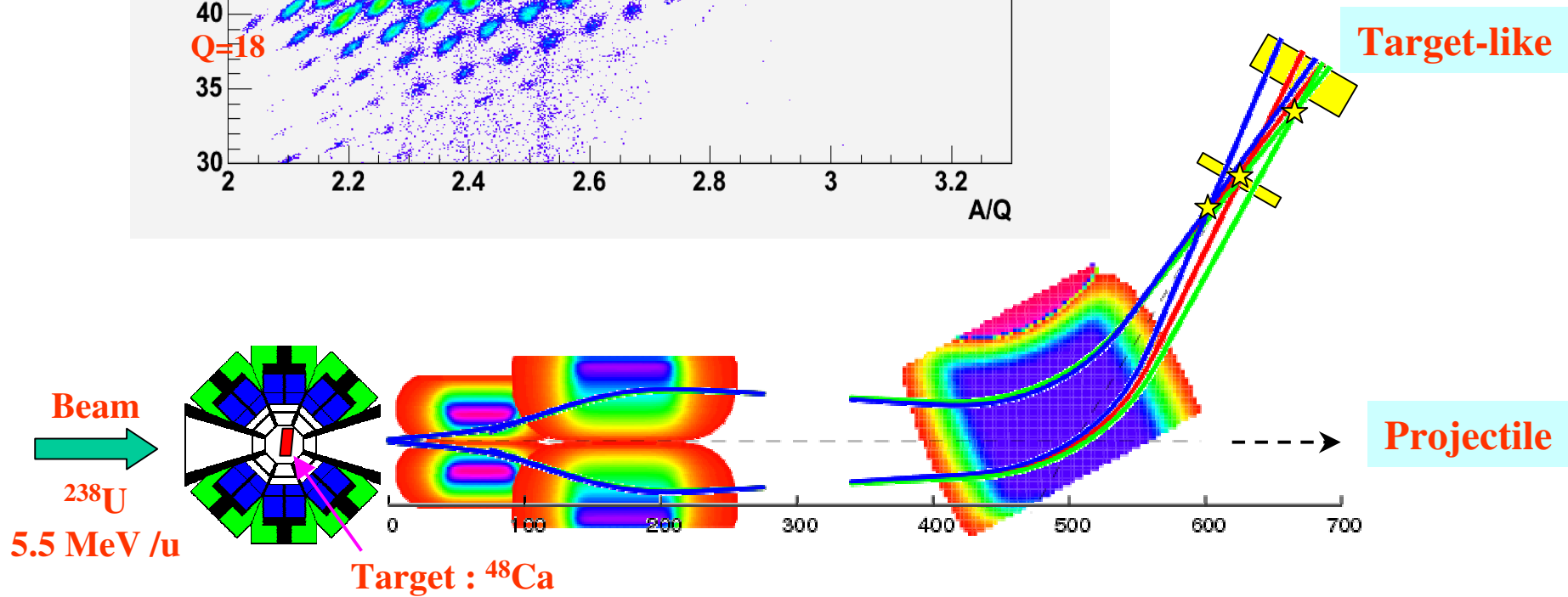
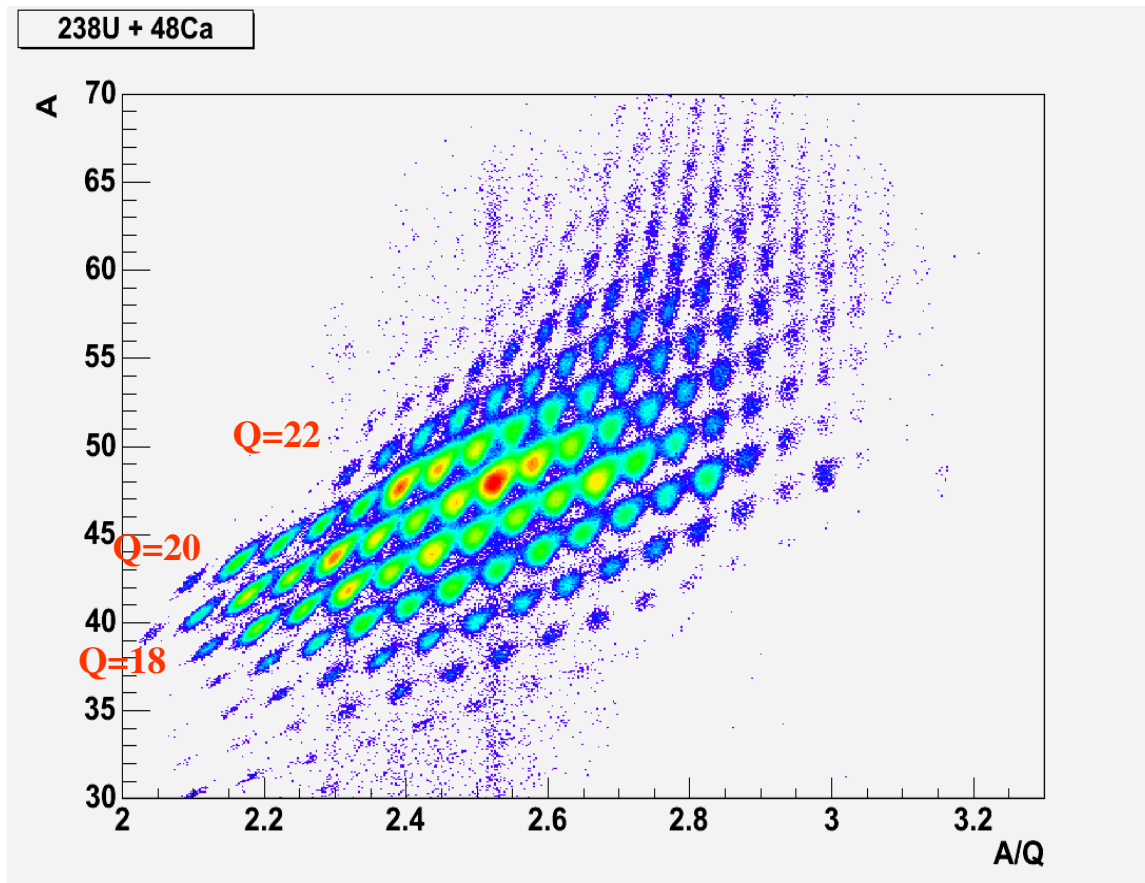
Doppler correction done event by event:

- Angle : velocity of fragment (VAMOS) and segments of EXOGAM Clover
 - Opening angle (segment) - 9.9 deg
- Resolution of 2% at 1 MeV

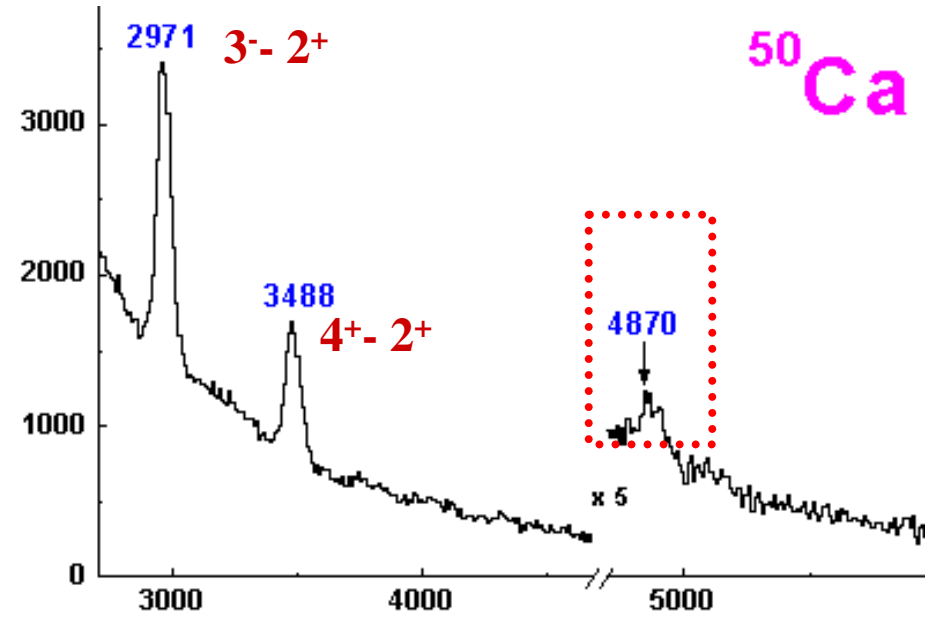
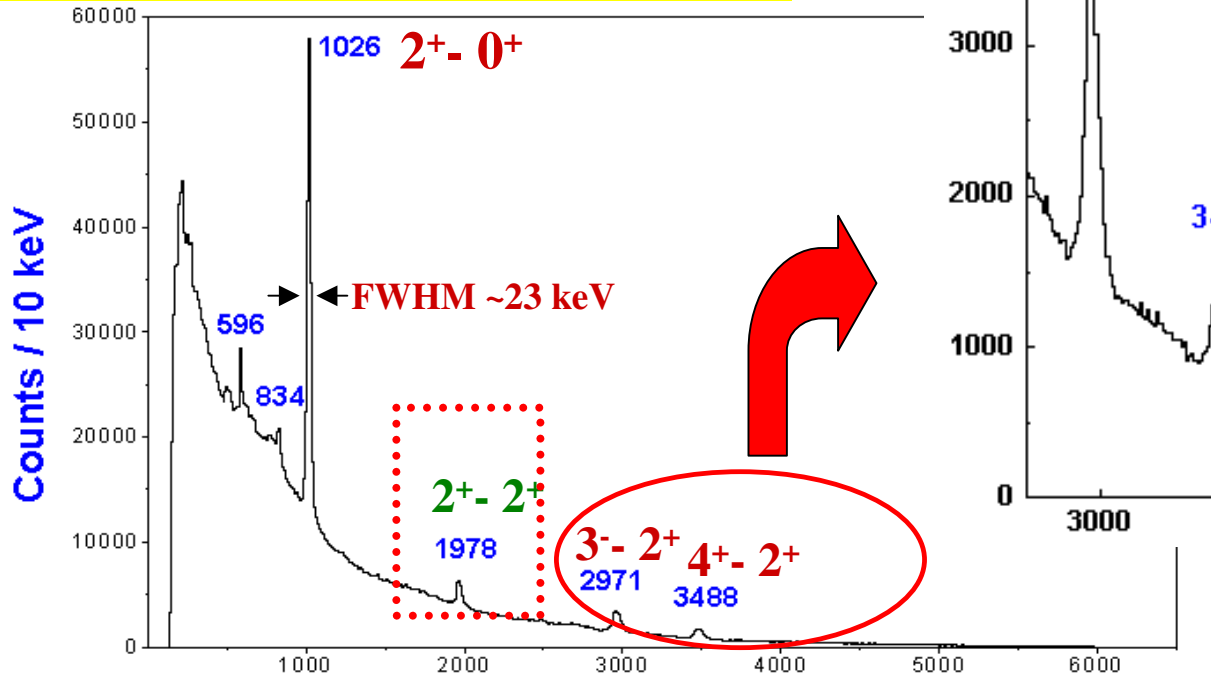




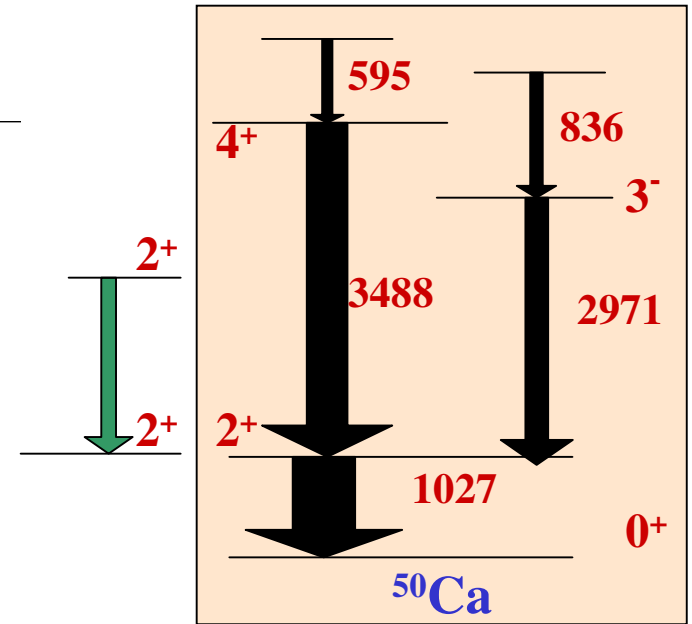
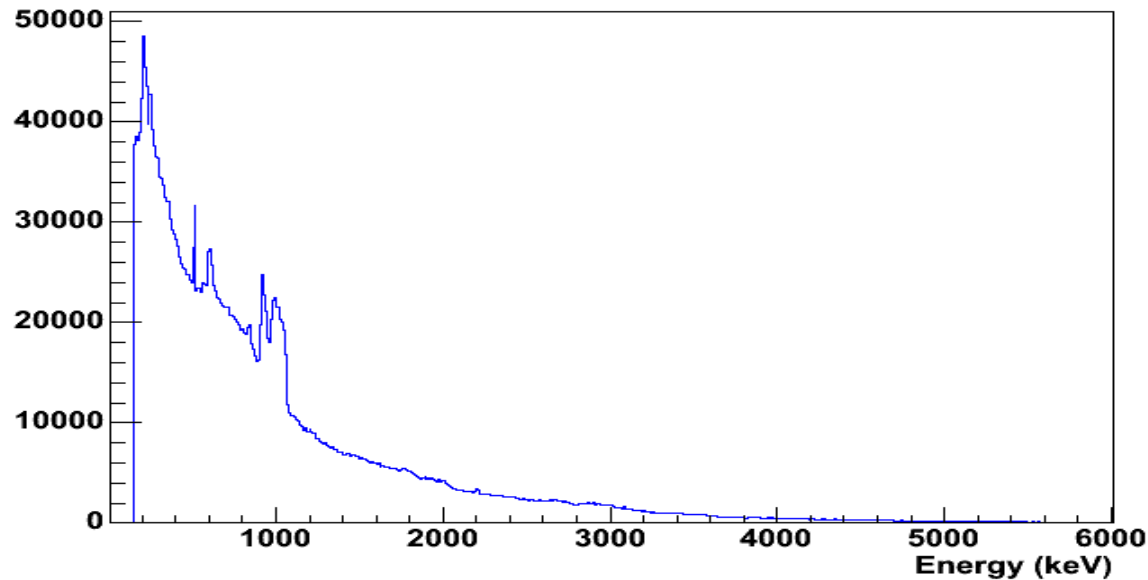
Direct Identification



Selectivity and Efficiency

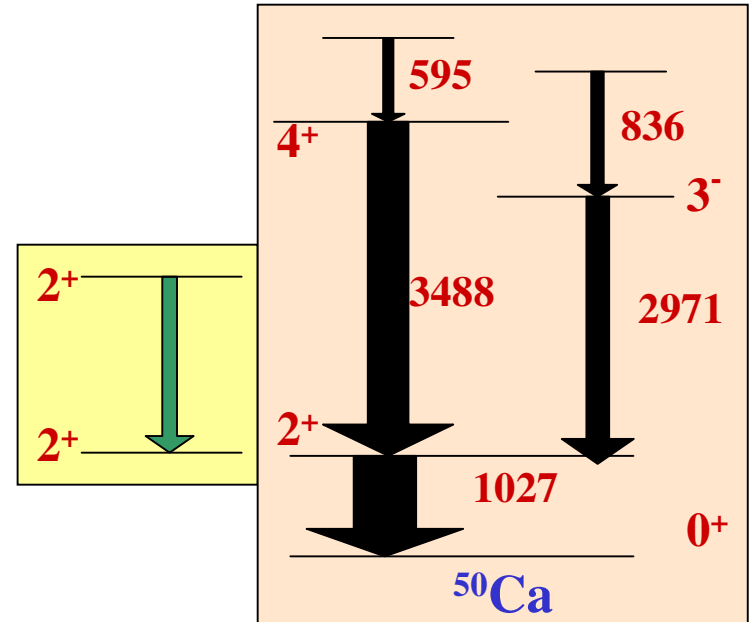
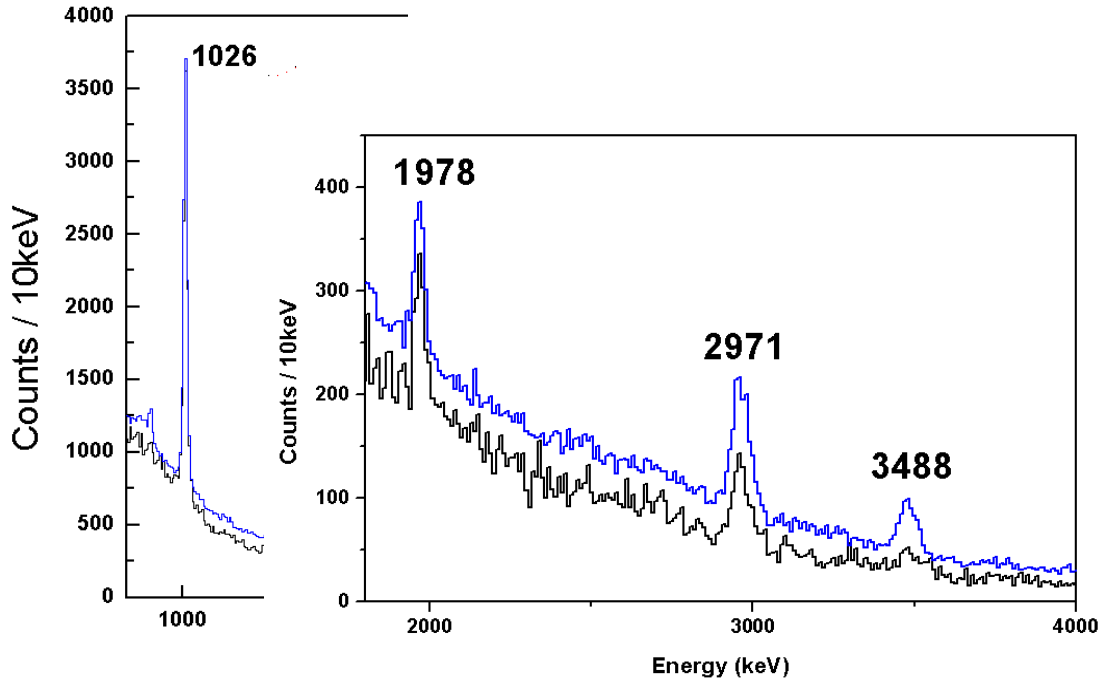


Gamma spectrum gates with ^{50}Ca - No Doppler Correction

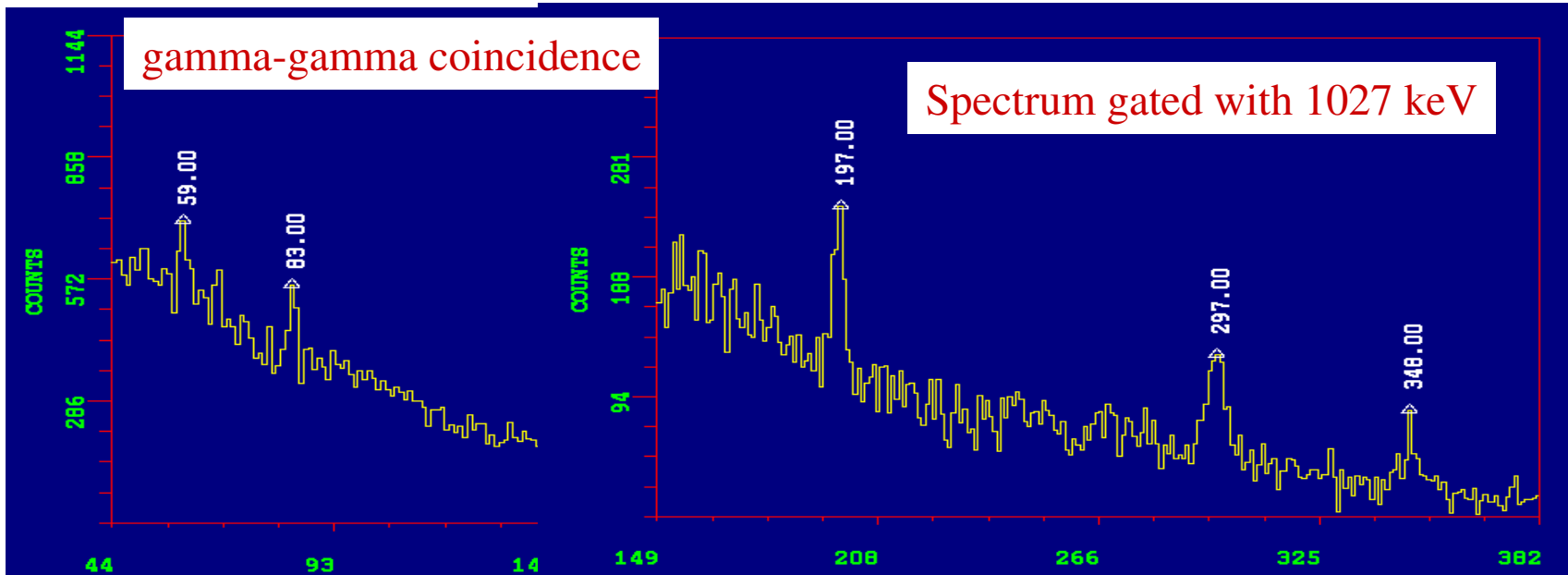


R. Broda et al., 2005

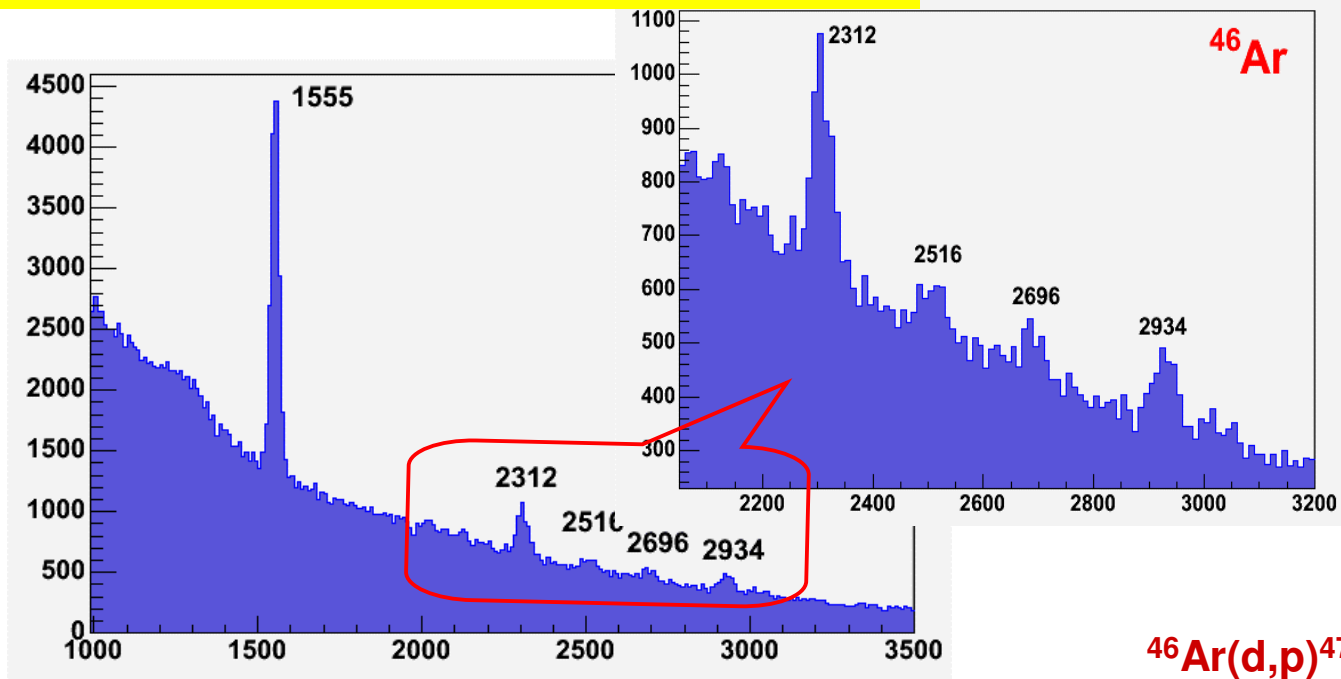
Population and feeding pattern



R. Broda et al., 2005

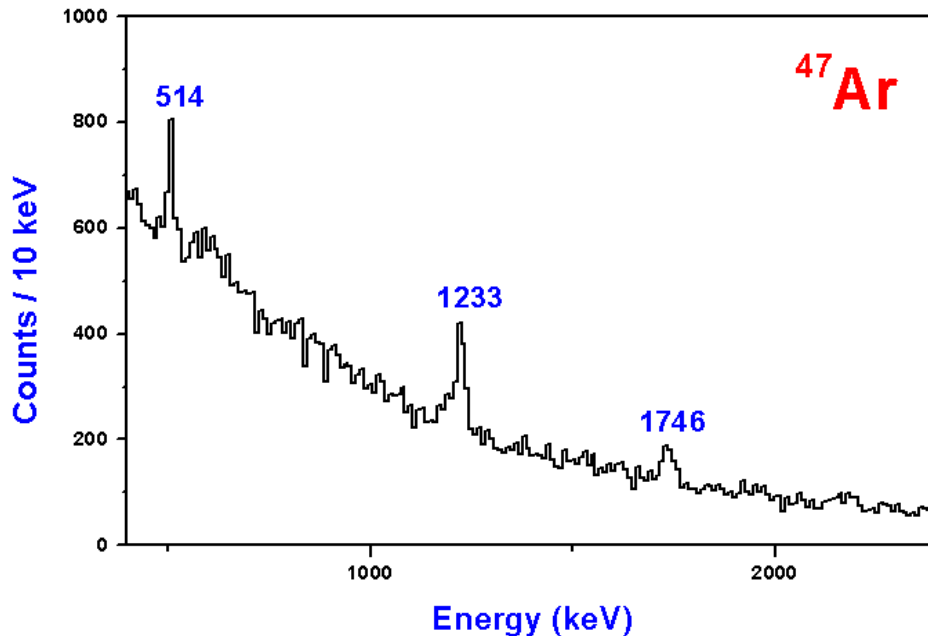


Many exciting results ... new limits



⁴⁸Ar
New !
(N/Z=1.666)

⁴⁶Ar(d,p)⁴⁷Ar (GANIL)



l=3	—	3335 (80)
l=1	—	2655 (80)
l=1	—	1740 (95)
l=1	—	1130 (75)
l=1	—	0

L. Gaudfrey et al.
Submitted to PRL

Conclusion and future perspectives

- *Deep Inelastic Reaction with ^{238}U beam on ^{48}Ca target at GANIL*
 - *EXOGRAM + VAMOS*
 - *Fragment - Gamma coincidence*
 - *High intensity ^{238}U beam*
 - *Gamma rays from excited states of*
50, 51, 52, ? Ca, S, Ar, Ti, Cr ($N/Z = 1.666$ and beyond)
 - *Very Exotic and seen for the first time !!*

- *High efficiency Spectrometer and Gamma-array*
Unique Identification of Very Exotic Nuclei

PATH TO STUDY SPECTROSCOPY OF UNKNOWN

..... Dream to Reality



*GAMMAPOOL WORKSHOP
ECT* Trento , May 2006*